

Oct. 21, 1958

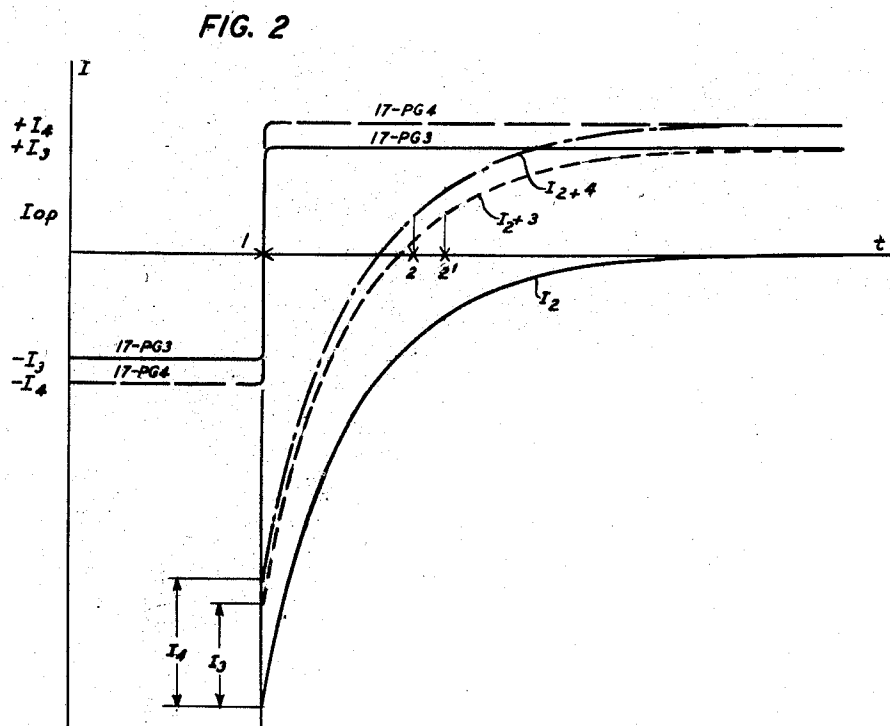
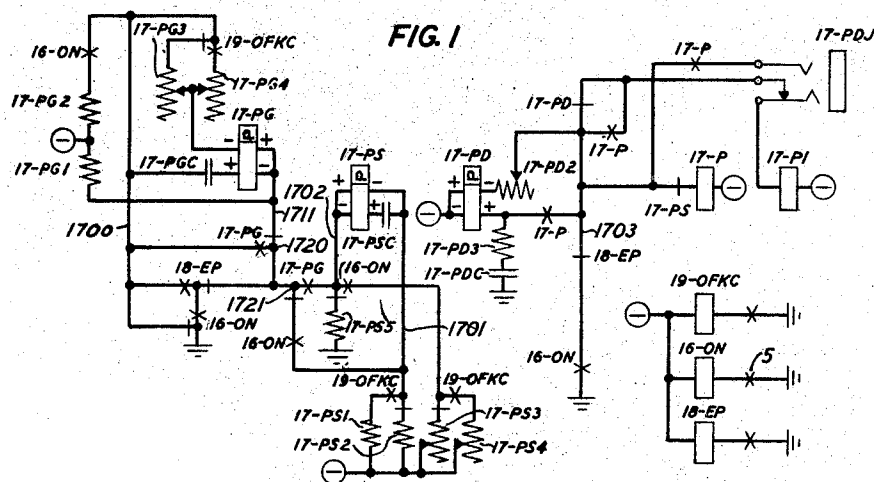
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2,857,529

TWO-SPEED PULSE GENERATOR

Filed Sept. 23, 1957

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FIG. 3

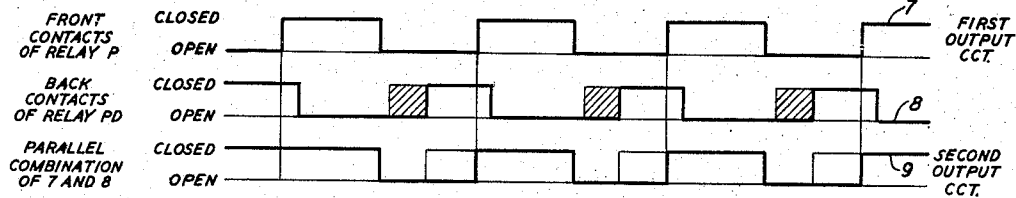


FIG. 4

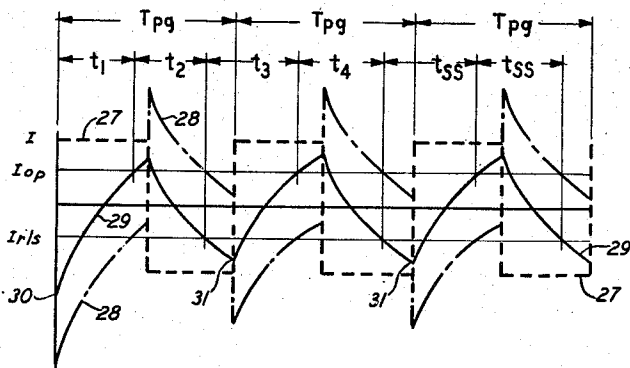
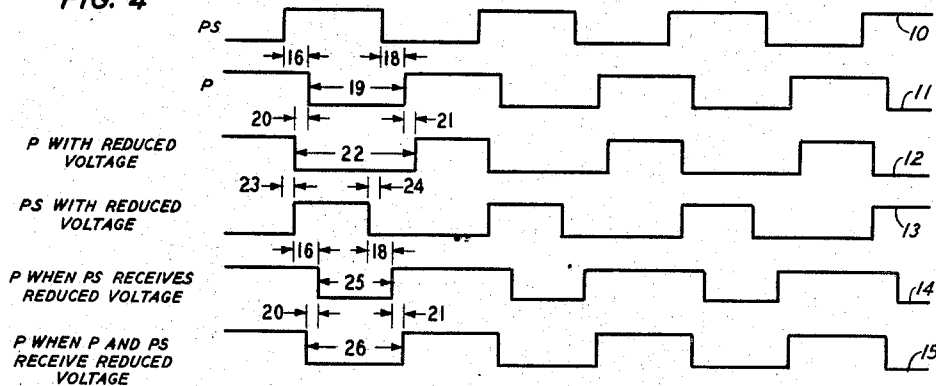


FIG. 5

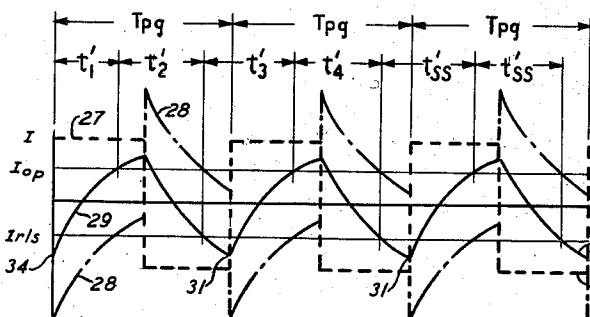


FIG. 6

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TWO-SPEED PULSE GENERATOR

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Application September 23, 1957, Serial No. 685,562

19 Claims. (Cl. 307—132)

This invention relates to apparatus for periodically opening and closing external electric circuits and more particularly to multiple-output pulsing apparatus operable at any one of a plurality of repetition rates.

Pulsing apparatus in which the make-to-break ratio can be varied independently of the pulsing rate has heretofore been proposed, illustrative of which is Patent 2,462,066, granted February 22, 1949 to F. H. Bray and F. E. Newton. Such pulsers are, however, rather complex in construction and are usually limited to the production at any one time of pulses having a single characteristic.

One general object of this invention is to improve and simplify such pulsers.

Another object of the invention is to provide a pulser capable of producing a plurality of output signals all having an identical pulsing rate but independently variable with respect to their percent breaks. "Percent break" means the ratio, expressed as a percent, of the length of time during one cycle that a circuit is open to the period of the cycle.

Still another object of the invention is to provide a pulser having a repetition rate which is independent of changes in the percent of the output.

Yet another object of the invention is to provide a pulser having an output percent break which is substantially independent of changes in the input supply voltage.

A further object of the invention is to provide a pulser which establishes a substantially steady-state condition before the beginning of the latter portion of the initial cycle in order that such latter portion of the initial cycle may be utilized as a dependable timing pulse.

Accordingly, in accordance with one feature of the invention a uniform pulsing rate is provided through the use of a first resistance-capacitance timed pulsing relay in combination with a symmetrical pulsing circuit.

According to another feature of the invention a variable impedance element is included in the operating circuit of a second pulsing relay. The second relay is driven by the first relay. A variation in the impedance of the element results in a corresponding variation in the percent break of the contacts of the second relay without affecting the repetition rate of those contacts.

According to a further feature of the invention two output signals having the same pulsing rate but having independently variable percent breaks are provided by taking the first of such signals from the output of the second relay and by taking the second of such signals from a parallel combination of the first signal and the output of a third pulsing relay. The third relay is driven by the second relay. A variable impedance element for the control of the percent break of the contacts of the third relay is provided in the third relay circuit.

According to still another feature of the invention variations in percent break due to fluctuations in the input supply voltage are effectively minimized by the provision of a conventional fourth relay having front contacts which are included in an output circuit, said fourth

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relay being operated by back contacts on the second pulsing relay.

According to still a further feature of the invention a voltage dividing circuit maintains on a timing capacitor included in the timing winding circuit of the second pulsing relay a charge which, during quiescent periods, is substantially the same as the maximum charge which resides on such capacitor during steady-state operations, thereby ensuring that an essentially steady-state condition is established before the beginning of the latter portion of the initial cycle. The duration of the latter portion of each cycle is controlled in part by the discharge of said capacitor. The stabilization of the maximum charge on such capacitor before the beginning of the latter portion of the initial cycle permits the use of such portion of such cycle as a reliable timing pulse.

The present specification describes and the accompanying drawings disclose in detail a relay pulser that is also disclosed in copending application, Serial No. 658,384, filed on May 10, 1957 by H. D. Cahill and C. H. Dagnall, Jr. for an Automatic Number Identifier. Only as much of the details of the identifier as is necessary to convey a complete understanding of the mode of operation and the nature of the use of the pulser is included in the present specification, and reference may be made to said copending application, Serial No. 658,384 for a complete understanding of the particular use of the present invention in connection with number identification.

The invention comprises three double-winding polar pulsing relays having well-known resistance-capacitance timing. The pulsing relays are arranged in combination with a conventional relay. The first pulsing relay, which operates as a free-running pulse generator, has a symmetrical circuit which produces pulses of substantially uniform period. The pulsing rate of the generator is adjustable within limits. Means are provided for selecting one or the other of any two preset rates which are within such limits. The first pulsing relay drives the second through transfer contacts on the first which are included in the winding circuits of the second. The second pulsing relay drives the conventional relay through back contacts on the second which are included in the winding circuit of the conventional relay. The conventional relay drives the third pulsing relay through front contacts on the conventional relay which are included in the winding circuits of the third pulsing relay.

Variable impedance elements in the circuits of each of the second and third pulsing relays control the percent break of the contacts associated with their respective relays but are ineffective to alter the pulsing rate since the second and third pulsing relays are effectively "slaved" to the generator, whose pulsing rate is independent of changes in the slaved circuits. The first of two outputs is taken from front contacts on the conventional relay. The second output is taken from a parallel combination of front contacts on the conventional relay and back contacts on the third pulsing relay.

A more complete understanding of the structure and operation of the invention will be obtained from the following detailed description of one particular embodiment of the invention and the drawings in which:

Fig. 1 is a schematic diagram of the invention as disclosed in Fig. 17 of application, Serial No. 658,384;

Fig. 2 is a diagram of the current waveforms in the windings of the first pulsing relay;

Fig. 3 is a diagram of the two output waveforms and their relationship;

Fig. 4 is a diagram illustrating a method of compensation for supply voltage fluctuations; and

Figs. 5 and 6 are diagrams of waveforms illustrating the effect on the uniformity of initial output pulses of pre-

setting the charge on a capacitor in the timing circuit of the second pulsing relay.

Now turning to Fig. 1, it should be noted that the descriptive nomenclature of copending application, Serial No. 658,384 has been utilized herein wherever possible. The numerical prefix 17, hereinafter appearing, refers to Fig. 17 of the copending application. The operation of the identifier which is disclosed in that application is controlled by the aforementioned set of pulsing relays comprising pulse generator relay 17-PG, pulse steering relay 17-PS, and pulse detector control relay 17-PD.

The pulse generator relay 17-PG is a resistance-capacitance timed polar relay of the well-known type. Relay 17-PG controls two sets of transfer contacts, namely, contacts 1720, which control the operation of relay 17-PG itself, and contacts 1721, which control the pulse steering relay 17-PS. Prior to the operation of off-normal relay 16-ON, a circuit exists from battery through resistor 17-PG1, conductor 1711, the lower winding of relay 17-PG, capacitor 17-PGC, conductor 1700, to back contacts 16-ON and ground. Capacitor 17-PGC is charged in this circuit. A circuit also exists from battery through resistor 17-PG1, conductor 1711, the upper winding of relay 17-PG, and adjustable resistor 17-PG3, to the back contacts of office check relay 19-OFKC and ground on conductor 1700. The current flow in the upper winding of polar relay 17-PG holds transfer contacts 1720 and 1721 in their back, or normally closed, positions.

Contacts 5 are closed in the winding circuit of off-normal relay 16-ON whenever it is desired to operate the pulser. As soon as relay 16-ON operates, ground is connected over front contacts 16-ON, back contacts 18-EP, back transfer contacts 1720, and conductor 1711, to the windings of relay 17-PG, thereby shunting to ground battery current which was flowing through resistor 17-PG1 and both windings of relay 17-PG. The operation of relay 16-ON also results in the disconnection of ground from conductor 1700 and the connection of battery through resistor 17-PG2 and front contacts 16-ON to conductor 1700. This connection of battery to conductor 1700 and the connection of ground to conductor 1711, as mentioned above, results in the reversal of the direction of current flow in both of the windings of relay 17-PG. The upper winding of relay 17-PG now energizes in a direction to cause the front contacts of transfer contacts 1720 to close but initially the magnetic flux produced by this current flow in the upper winding of relay 17-PG is opposed by an opposite magnetic flux produced by the current flow through the lower winding as capacitor 17-PGC discharges and recharges in the opposite polarity. Therefore, a timed interval occurs between the reversal of the potential applied to conductors 1700 and 1711 and the operation of relay 17-PG, which interval extends until capacitor 17-PGC is sufficiently charged, the current flow in the lower winding becomes small, and relay 17-PG operates, closing front transfer contacts 1720.

When front contacts 1720 are closed, ground is reconnected to conductor 1700 over front contacts 16-ON, back contacts 18-EP, and front transfer contacts 1720. The closure of front contacts 1720 also results in the removal of ground from conductor 1711, which returns to battery potential as supplied through resistor 17-PG1. The operation of relay 17-PG thus restores the relative polarity between conductors 1700 and 1711 thereby restoring the direction of energization of the upper winding of relay 17-PG. This restoration causes back transfer contacts 1720 to close and front contacts 1720 to open. As before, the reversal of the energization of the lower winding of relay 17-PG causes capacitor 17-PGC to discharge and recharge, thereby delaying the effect of the upper winding. But with back transfer contacts 1720 closed relay 17-PG stands in the same position as it did when relay 16-ON was operated. Accordingly, the above cycle of opening and closing transfer contacts 1720

and reversing the polarities on conductors 1700 and 1711 repeats and continues to repeat until relay 18-EP is operated by the aforementioned identifier or relay 16-ON is released.

Referring now to Fig. 2, a somewhat idealized current-time diagram depicts the timing effect of the above-described capacitor discharge on the double-winding pulsing relay 17-PG. The current $-I_3$ flows through resistor 17-PG3 and the upper winding of relay 17-PG whenever ground is connected to conductor 1700 and battery to conductor 1711. The current $+I_3$ flows whenever these connections are reversed by the operation of transfer contacts 1720. Currents $-I_4$ and $+I_4$ respectively flow in a lower valued resistor 17-PG4 and the upper winding of relay 17-PG whenever office check relay 19-OFKC is operated by the identifier. The current $+I_{op}$ is the amount by which the magnitude of a current in the upper winding of relay 17-PG must exceed an oppositely poled current flowing in the lower winding for relay 17-PG to operate and close its front transfer contacts. The current I_2 is the charging current flowing in capacitor 17-PGC and the lower winding of relay 17-PG immediately after the polarity of conductors 1700 and 1711 reverses.

As has been hereinbefore described in connection with Fig. 1 the operation of the transfer contacts of relay 17-PG accomplishes this alternate reversal of polarity of conductors 1700 and 1711. Referring to instant 1 on the current-time diagram of Fig. 2, and considering this to be an instant when such an aforementioned transfer takes place it may be seen that substantially instantaneously a discharge current I_2 flows in the lower winding of relay 17-PG in a sense which adds to the flux produced by a similarly poled current in the upper winding. The current in the upper winding, however, under the influence of a reversed applied voltage, on conductors 1700 and 1711, reverses as quickly thereafter as the inductance of the upper winding will permit. This effect is comparatively small and has been neglected in Fig. 2. The curves I_{2+3} and I_{2+4} represent the algebraic sum, considering their relative magnetizing effects, of charging current I_2 in the lower winding and currents I_3 and I_4 , respectively, in the upper winding. When either of these curves intersects current level I_{op} , representing sufficient flux to move the armature of relay 17-PG, relay 17-PG operates, transfer contacts 1720 operate, and the polarity of conductors 1700 and 1711 reverses. This reversal, which is not shown in Fig. 2, causes the entire operation shown in the figure to begin again but with opposite polarities. Hence the time between instants 1 and 2 or 2', as the case may be, represents one-half period of the pulsing cycle. Thus it may be seen that the length of the pulsing period and consequently the pulsing rate may be selected by varying the size of the resistance in series with the upper winding. In practice, this is accomplished by selecting one or the other of resistances 17-PG3 or 17-PG4 through the operation or release of relay 19-OFKC. Relay 19-OFKC is operated by the aforementioned number identifier at certain times during an identification when it is desired to alter the pulsing rate. The symmetrical nature of the circuit results in pulses having a 50 percent break.

Prior to the operation of relay 16-ON in Fig. 1, a circuit exists for the pulse steering relay 17-PS which may be traced from battery through resistor 17-PS2, back contacts 19-OFKC, conductor 1701, through the upper winding of pulsing relay 17-PS, and in parallel therewith through capacitor 17-PSC and the lower winding of relay 17-PS, conductor 1702, back contacts 16-ON, and resistor 17-PS5 to ground. The function of resistor 17-PS5 will be discussed in connection with Figs. 5 and 6. The current flow through the windings of polar relay 17-PS at this time is in a direction to hold its back contacts open.

As soon as relay 16-ON operates, the aforementioned

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circuit is opened at back contacts 16-ON and relay 17-PS is placed under the control of the pulse generating relay 17-PG through transfer contacts 1721 which operate whenever contacts 1720 operate. With relay 16-ON operated, battery through resistor 17-PS2 is connected over the back contacts of relay 19-OFKC to conductor 1701, which connects with the right terminal of the upper winding of relay 17-PS and with capacitor 17-PSC, while battery through resistor 17-PS3 is connected over the back contacts of relay 19-OFKC and the front contacts of relay 16-ON to conductor 1702, which is connected to the left terminals of both windings of relay 17-PS.

It should be recalled that transfer contacts 1721 alternately operate and release under the control of pulse generating relay 17-PG. Accordingly, when back transfer contacts 1721 are closed, ground is connected over front contacts 16-ON, back contacts 18-EP, back transfer contacts 1721, to front contacts 16-ON and conductor 1701, thereby grounding conductor 1701, notwithstanding its aforementioned connection to battery. When front transfer contacts 1721 are closed, ground is connected over front contacts 16-ON, back contacts 18-EP, to front transfer contacts 1721 and conductor 1702, thereby grounding conductor 1702, notwithstanding its aforementioned connection to battery. It should be noted that when not grounded each of conductors 1701 and 1702 are at battery potential through resistors 17-PS2 and 17-PS3, respectively. Thus the operation of transfer contacts 1721, in response to the aforementioned operation of pulse generating relay 17-PG, serves to periodically reverse the voltage applied to conductors 1701 and 1702 and correspondingly to the windings of relay 17-PS. This causes relay 17-PS to open and close its back contacts once each cycle in much the same way as relay 17-PG operates. The magnetizing effect of the current flow through the lower winding of relay 17-PS and capacitor 17-PSC opposes the magnetizing effect of the current flow through the upper winding of relay 17-PS and serves to delay by a measured interval either the opening or the closing of the relay contacts. This delay may be altered by adjusting variable resistor 17-PS3, or 17-PS4 when relay 19-OFKC is operated by the identifier, as hereinbefore indicated.

The operation of relay 16-ON closes a circuit from battery through the upper winding of relay 17-PD, adjustable resistor 17-PD2, conductor 1703, back contacts 18-EP, to ground over front contacts 16-ON. The operation of relay 16-ON also results in the operation of relay 17-P1 over a path from ground through front contacts 16-ON, back contacts 18-EP, conductor 1703, back contacts 17-PD, the lower contacts of jack 17-PDJ, to the winding of relay 17-P1 and battery. The lower winding of relay 17-PD is included in a circuit from battery through the lower winding of relay 17-PD, resistor 17-PD3, to capacitor 17-PDC and ground. At the time relay 16-ON operates, connecting ground to conductor 1703 on the one hand and causing relay 17-PS to hold its back contacts closed on the other, as above described, a circuit is closed from battery through the winding of relay 17-P, back contacts 17-PS, to conductor 1703 and ground, as above traced, thereby operating relay 17-P. Because of the presence of contacts of relay 17-PS in its winding circuit relay 17-P is under the control of relay 17-PS and operates whenever that relay releases. With relay 17-P operated, an auxiliary path for relay 17-P1 is extended from ground on conductor 1703 through the front contacts of relay 17-P, the lower contacts of jack 17-PDJ (the second output circuit of Fig. 3), to the winding of relay 17-P1 and battery. Ground is also extended over front contacts 17-P to the upper contacts of jack 17-PDJ (the first output circuit of Fig. 3). Additional relays (not shown) could be connected in parallel with relay 17-P1 to provide any required number of

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contacts in a plurality of external circuits such as the circuits of the aforementioned identifier.

When relay 17-P is operated, in response to the release of relay 17-PS, ground on conductor 1703 is also connected to the lower winding of relay 17-PD, thereby shunting the capacitor 17-PDC and causing the capacitor to discharge. This last-mentioned connection also results in the energization of the lower winding of relay 17-PD. As a result of the energization of the lower winding of relay 17-PD, that relay operates and opens its back contacts. Thus it may be seen that pulsing relay 17-PD is under the control of conventional relay 17-P.

As above described, relay 17-PG alternately closes its back and front transfer contacts 1721 causing relay 17-PS to alternately close and open its back contacts. At the opening of the back contacts of relay 17-PS, the circuit of relay 17-P is opened and that relay releases. Since the back contacts of relay 17-PD are also open, the release of relay 17-P causes the release of relay 17-P1. The function of relay 17-P will be hereinafter discussed in connection with Fig. 4. The release of relay 17-P also disconnects ground from the lower winding of relay 17-PD so that capacitor 17-PDC charges through the lower winding of relay 17-PD. The charging current is in a direction to hold the back contacts of relay 17-PD open and when the current decreases, after a measured interval, the upper winding of relay 17-PD causes the back contacts to reclose, completing the above-described principal circuit for operating relays 17-P1. This interval may be altered by adjusting variable resistor 17-PD2 thereby changing the biasing current in the upper winding of relay 17-PD.

When relay 17-PS again closes its back contacts, relay 17-P reoperates, again connecting ground to the lower winding of relay 17-PD, thereby causing that relay to open its back contacts. The opening of the back contacts of relay 17-PD opens the auxiliary circuit for relay 17-P1, but relay 17-P at its front contacts has already reclosed the original circuit for the relay. This operation will be referred to again in connection with an explanation of Fig. 3.

The pulsing continues until the pulse generator is stopped by the release of relay 16-ON or the operation of relay 18-EP, which might be an overriding cancelling control in the aforementioned identifier. Relay 17-P, which operates and releases under the control of relays 17-PG and 17-PS, could control the operation of the office and digit steering relays in the identifier, permitting the identifier to scan certain output conductors of a number network which is disclosed in said aforementioned copending application.

In Fig. 3, waveform 7 represents the output of relay 17-P as measured on the front contacts thereof. These contacts also control the operation of pulsing relay 17-PD as hereinbefore described. Waveform 8 represents the output of relay 17-PD as measured on the back contacts thereof. Comparing waveforms 7 and 8, it may be seen that shortly after relay 17-P operates, closing its front contacts, relay 17-PD operates, opening its back contacts. When relay 17-P releases and opens its front contacts, relay 17-PD does not immediately release. This delay is because of the effect of the discharge current flowing through capacitor 17-PDC and the lower winding of relay 17-PD, as hereinbefore described. The extension in the open interval of the back contacts of relay 17-PD as a result of this delay is shown as a cross-hatched area in waveform 8. By suitably adjusting resistor 17-PD2, the extension in the open interval may be made to take any value between no delay (no cross-hatched area in 8) and a delay extending almost to the time of the next operation of relay 17-P.

The back contacts of relay 17-PD (waveform 8) and the front contacts of relay 17-P (waveform 7) are paralleled together to produce that output which appears on the lower contacts of jack 17-PDJ and which operates relay 17-P1 in the aforementioned identifier circuit. The

circuit for this combined output (waveform 9) can only be open when both contacts 7 and 8 are open. It should be noted that the second output (waveform 9) has the periodicity of waveform 7, which is the first output, but that its percent break is variable in consequence of adjustments in the value of resistor 17-PD2.

In Fig. 4, waveform 10 represents the operation of the contacts of relay 17-PS when normal voltage is applied to its windings. Waveform 11 shows the operation of conventional relay 17-P under the same conditions. The waveform for the latter relay is displaced slightly to the right because of the finite operate and release times involved. In each waveform of Fig. 4 a rise indicates the operation of the specified relay and a drop indicates a release of that same relay. It may be observed that except for the displacement to the right, waveform 11 is the inverse of waveform 10. This relationship exists because relay 17-P is driven by back contacts on relay 17-PS. Accordingly, relay 17-P releases a short interval 16 after relay 17-PS operates and interrupts the winding circuit of relay 17-P. Similarly, the operation of relay 17-P is also delayed a short interval 18. These delays are inherent in relay 17-P and are not adjustable as are the delays associated with the pulsing relays.

It is well known that one of the effects of a reduction in the amplitude of the voltage supplied to any relay is to increase the portion of each cycle during which such a relay remains unoperated. This amounts to a change in the percent break. When undesired, as in the present invention, it may be corrected by the use of back contacts for driving other relays supplied with the same reduced voltage. If the amplitude of the voltage supplied to relay 17-P is decreased without affecting that supplied to relay 17-PS, waveform 12 results. Just before relay 17-PS operates the current and the concomitant magnetic flux in the winding of relay 17-P have steady-state values which are less than normal because a smaller current flows when a reduced voltage is applied to the fixed impedance of the winding of relay 17-P. The magnitude of the flux decays from this lower value to the value at which the relay armature releases in less time 20 than is normally required 16. Correspondingly, upon the release of relay 17-PS, the magnetic flux in the winding of relay 17-P requires a longer time 21 than would normally be required 18 to build to a magnitude which is sufficient to operate the armature. These two effects increase the unoperated interval of the relay by an amount equal to (20+21) thereby changing the interval from 19 to 22.

Of course, in actual practice whenever a reduction in the amplitude of the voltage supplied to relay 17-PS takes place in any pulser such as the present invention a similar reduction would be experienced by relay 17-P, because normally all relays in a pulsing apparatus are supplied from the same voltage source. Waveform 13 depicts the effect of a reduction of voltage amplitude on the operation of relay 17-PS. When compared with the normal waveform of relay 17-PS, shown in 10, it may be observed that the time required for operation has increased by an amount 23 and the time required for release has decreased by an amount 24 in a fashion similar to that described for relay 17-P. By analogy with the waveforms 10 and 11 and ignoring the effect on relay 17-P of the reduced voltage amplitude it may be seen in waveform 14 that the reduction in the operated time of relay 17-PS has correspondingly reduced the released time 25 of relay 17-P. The interval 25 is smaller than the interval 19 by an amount equal to (23+24).

The effect of the reduced voltage on relay 17-P is added in 15. A reduction in the amplitude of the voltage supplied to relay 17-PS tends to decrease the unoperated interval of relay 17-P (waveform 14) and a reduction in the amplitude of the voltage supplied to relay 17-P tends to increase this same interval (waveform 12). These effects are oppositely directed because relay 17-P is driven by relay 17-PS through back contacts that cause

the inversion. The more closely the interval (23+24) is made to approach the interval (20+21) the smaller is the effect of a voltage amplitude decrease on the percent break. Of course, the foregoing discussion concerning Fig. 4 applies equally well to increases in the amplitude of the voltage supplied for the effects of a voltage change on the two relays are always oppositely directed.

When the present invention is used in connection with the aforementioned identifier it is important that the pulser establish a substantially steady-state condition before the beginning of the latter portion of the initial cycle in order that timing in the identifier may begin with such latter portion of the initial cycle. Fig. 5 depicts in an idealized fashion the current waveforms in the upper and lower windings of relay 17-PS when set for a 50 percent break. Since relay 17-PS drives relay 17-P which in turn controls the output, it is necessary that relay 17-PS establish a steady-state condition within a short time after relay 16-ON is operated. In Fig. 5 curve 27 represents the current in the upper or biasing winding, curve 28 represents the current in the lower or timing winding, and curve 29 represents the algebraic sum, considering their relative magnetizing effects, of currents 27 and 28. I_{op} is the current value at which relay 17-PS will operate. Similarly I_{rls} is the current value at which the relay will release.

When the circuit is in the quiescent state it is desired that the first and second output circuits remain open. This condition requires that relay 17-P remain unoperated. Correspondingly, relay 17-PS must remain operated in order that its back contacts in the operating winding circuit of relay 17-P stand open. Current will flow through the upper or operating winding of relay 17-PS only in the event conductor 1702 is connected to ground. However, if conductor 1702 is connected directly to ground the full voltage between conductor 1701 and ground will appear across the windings of relay 17-PS and capacitor 17-PSC will charge to such voltage. This voltage will be considerably larger than the maximum voltage to which the capacitor will have time to charge during steady-state operations. Further, this voltage, when added to an oppositely poled voltage applied upon the operation of transfer contacts 1721, will result in a larger voltage differential across the impedance of the charging circuit of capacitor 17-PSC than would exist following subsequent operations of contacts 1721. The larger voltage would result in a larger peak value 30 of charging current 29 in the negative region of Fig. 5 than that which obtains later at 31, under substantially steady-state conditions.

In Fig. 5 starting from a more negative value at point 30, the composite winding current 29 requires a longer time, relative to the period T_{pg} of relay 17-PG, to reach the I_{op} level, than it requires to reach that same level when starting from the steady-state peak value 31. The duration (t_2+t_3) , (t_3+t_4) , (t_4+t_{ss}) or $2t_{ss}$ must always equal T_{pg} , the period of the repetition rate at which pulse generating relay 17-PG is operating. Further, the interval (t_1+t_2) is fixed, being determined by the decay of 29 from the reversal of 27. Hence an increase in the time t_1 , caused by the initial depression in the composite winding current curve 29 for relay 17-PS, can only result in a reduction in the duration of the t_2 interval.

This reduction is undesirable since the aforementioned identifier uses t_2 , t_4 , and t_{ss} as timing pulses which must be uniform. This uniformity is obtained in Fig. 1 by inserting resistor 17-PS5 in a circuit joining conductor 1701 and ground through the windings of relay 17-PS. Whenever relay 16-ON is unoperated and the pulser is quiescent, current flows from ground through resistor 17-PS5, conductor 1702, the upper winding of relay 17-PS, conductor 1701, to resistor 17-PS2 and battery. Thus resistor 17-PS5 and the upper winding of relay 17-PS serve to divide the potential which exists between

conductor 1701 and ground. The value of the resistor is chosen in such a manner that the potential across the upper winding of relay 17-P₃ and hence across capacitor 17-PSC, is approximately equal to the voltage across capacitor 17-PSC at the beginning of each cycle during steady-state operations. The effect of the resultant reduction in initial peak current 30 in composite curve 29, may be seen in Fig. 6 where peak current 34 is substantially the same as steady-state peak current 31. Thus t_2' is made to equal t_4' and t_{ss}' , satisfying the number identifier requirements.

The invention has been described above with reference to a particular embodiment thereof as incorporated in the aforementioned automatic number identifier. It will be evident, however, to one skilled in the art that said invention is not limited to the particular embodiment nor to the particular number identifier referred to in connection therewith, but that various applications, modifications, and arrangements other than those disclosed herein are within the scope of the invention.

What is claimed is:

1. A device for periodically opening and closing an external electric circuit comprising first and second relays, means including contacts of said first relay for producing periodic oscillations of the armature of said first relay, means including said second relay and contacts associated with said armature of said first relay for producing periodic oscillations of the armature of said second relay, and means included in said last-mentioned means for varying the percent break of said armature of said second relay.

2. Apparatus according to claim 1 wherein said percent break varying means comprises a variable impedance element.

3. A device for periodically opening and closing an external electric circuit comprising first and second double winding pulsing relays, means including contacts of said first relay for producing periodic oscillations of the armature of said first relay, means for varying the period of said oscillations, means including said second relay and contacts associated with said armature of said first relay for producing periodic oscillations of the armature of said second relay, means included in said last-mentioned means for varying the percent break of said armature of said second relay, and contacts included in said external circuit and responsive to the operation of said armature of said second relay for periodically opening and closing said circuit.

4. Apparatus according to claim 3 wherein said percent break varying means comprises a variable impedance element.

5. A device for periodically opening and closing a plurality of external electric circuits comprising first, second, and third double winding pulsing relays, means including contacts of said first relay for producing periodic oscillations of the armature of said first relay, means for varying the period of said oscillations, means including said second relay and contacts associated with said armature of said first relay for producing periodic oscillations of the armature of said second relay, means included in said last-mentioned means for varying the percent break of said armature of said second relay, means including said third relay and contacts associated with said armature of said second relay for producing periodic oscillations of the armature of said third relay, and means included in said last-mentioned means for varying the percent break of said armature of said third relay.

6. Apparatus according to claim 5 wherein said oscillation period varying means and said percent break varying means comprise variable impedance elements.

7. A device for periodically opening and closing a plurality of external electric circuits comprising first, second, and third double winding pulsing relays, means including contacts of said first relay for producing peri-

odic oscillations of the armature of said first relay, means for varying the period of said oscillations, means including said second relay and contacts associated with said armature of said first relay for producing periodic oscillations of the armature of said second relay, means included in said last-mentioned means for varying the percent break of said armature of said second relay, means including said third relay and contacts associated with said armature of said second relay for producing periodic oscillations of the armature of said third relay, means included in said last-mentioned means for varying the percent break of said armature of said third relay, a first set of contacts included in a first one of said plurality of circuits responsive to the operation of said armature of said second relay, and a second set of contacts included in a second one of said plurality of circuits responsive to the operation of said armature of said third relay.

8. Apparatus according to claim 7 wherein said oscillation period varying means and said percent break varying means comprise variable impedance elements.

9. A device for periodically opening and closing a plurality of external electric circuits comprising first, second, and third double winding pulsing relays, means including contacts of said first relay for producing periodic oscillations of the armature of said first relay, means for varying the period of said oscillations, means including said second relay and contacts associated with said armature of said first relay for producing periodic oscillations of the armature of said second relay, means included in said last-mentioned means for varying the percent break of said armature of said second relay, means including said third relay and contacts associated with said armature of said second relay for producing periodic oscillations of the armature of said third relay, means included in said last-mentioned means for varying the percent break of said armature of said third relay, a first set of contacts included in a first one of said plurality of circuits responsive to the operation of said armature of said second relay, a second set of contacts included in a second one of said plurality of circuits responsive to the operation of the armature of said third relay, and a third set of contacts included in parallel with said second set of contacts in said second circuit responsive to the operation of said armature of said second relay.

10. Apparatus according to claim 9 wherein said oscillation period varying means and said percent break varying means comprise variable impedance elements.

11. Apparatus according to claim 9 wherein said oscillation period varying means comprises a plurality of different variable impedance elements selectively includable in said periodic oscillation producing means.

12. A device for periodically opening and closing a plurality of external electric circuits comprising first, second, and third double winding pulsing relays, a fourth relay, means including contacts of said first relay for producing periodic oscillations of the armature of said first relay, means for varying the period of said oscillations, means including said second relay and contacts associated with said armature of said first relay for producing periodic oscillations of the armature of said second relay, means included in said last-mentioned means for varying the percent break of said armature of said second relay, means including the contacts associated with said armature of said second relay for producing periodic oscillations in the armature of said fourth relay, means including said third relay and contacts associated with said armature of said fourth relay for producing periodic oscillations of the armature of said third relay, and means included in said last-mentioned means for varying the percent break of said armature of said third relay.

13. Apparatus according to claim 12 wherein said oscillation period varying means and said percent break varying means comprise variable impedance elements.

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14. Apparatus according to claim 12 wherein said oscillation period varying means comprises a plurality of different variable impedance elements selectively includable in said periodic oscillation producing means.

15. A device for periodically opening and closing a plurality of external electric circuits comprising first, second, and third double winding pulsing relays, a fourth relay, means including contacts of said first relay for producing periodic oscillations of the armature of said first relay, means for varying the period of said oscillations, means including said second relay and contacts associated with said armature of said first relay for producing periodic oscillations of the armature of said second relay, means included in said last-mentioned means for varying the percent break of said armature of said second relay, means including the contacts associated with said armature of said second relay for producing periodic oscillations in the armature of said fourth relay, means including said third relay and contacts associated with said armature of said fourth relay for producing periodic oscillations of the armature of said third relay, means included in said last-mentioned means for varying the percent break of said armature of said third relay, a first set of contacts included in a first one of said plurality of circuits responsive to the operation of said armature of said fourth relay, a second set of contacts included in a second one of said plurality of circuits responsive to the operation of said armature of said third relay, and a third set of contacts included in parallel with said second set of contacts in said second circuit responsive to the operation of said armature of said fourth relay.

16. Apparatus according to claim 15, wherein said

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oscillation period varying means and said percent break varying means comprise variable impedance elements.

17. Apparatus according to claim 15 wherein said oscillation period varying means comprises a plurality of different variable impedance elements selectively includable in said periodic oscillation producing means.

18. A device for periodically opening and closing an external electric circuit comprising first and second relays, a capacitor associated with said second relay for delaying the operation and release thereof, means including contacts of said first relay for producing periodic oscillations of the armature of said first relay, means including said second relay and contacts associated with said armature of said first relay for producing periodic oscillations of the armature of said second relay, means including said capacitor for varying the percent break of said armature of said second relay, and means responsive to an unoperated condition of said device for maintaining a voltage upon said capacitor which is substantially equivalent in magnitude to the voltage maintained upon said capacitor at the beginning of each cycle when said device is operating under steady-state conditions.

19. In a relay pulse generator, a pulsing relay, a capacitor timing circuit for controlling the percent break of the output of said generator, and means operative when said generator is inactive for maintaining a voltage upon said capacitor which is substantially equivalent in magnitude to the voltage maintained upon said capacitor at the beginning of each cycle when said generator is operating under steady-state conditions.

No references cited.